General Relativity and Gravitation 2016 vol.48 N10

Equatorial geodesics in ergoregion of dirty black holes and zero energy observers

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Abstract

© 2016, Springer Science+Business Media New York.We consider equatorial motion of particles in the ergoregion of generic axially symmetric rotating black holes. We introduce the notion of zero energy observers (ZEOs) as counterparts to known zero angular observers (ZAMOs). It is shown that the trajectory of a ZEO has precisely one turning point that lies on the boundary of the ergoregion for photons and inside the ergoregion for massive particles. As a consequence, such trajectories enter the ergosphere from the white hole region under horizon and leave it crossing the horizon again (entering the black hole region). The angular velocity of ZEO does not depend on the angular momentum. For particles with E> 0 this velocity is bigger than for a ZEO, for E< 0 it is smaller. General limitations on the angular momentum are found depending on whether the trajectory lies entirely inside the ergoregion, bounces back from the boundary or intersects it. These results generalize the recent observations made in A. A. Grib, Yu. V. Pavlov, arXiv:1601.02592 for the Kerr metric. We also show that collision between a ZEO and a particle with E≠ 0 near a black hole can lead to the unbound energy in the centre of mass thus giving a special version of the Bañados-Silk-West effect.

http://dx.doi.org/10.1007/s10714-016-2130-6

Keywords

Ergoregion, Event horizon, Negative and zero energy